

National Aeronautics and Space Administration



# Space Technology

## Game Changing Development

### Rapid Analysis and Manufacturing

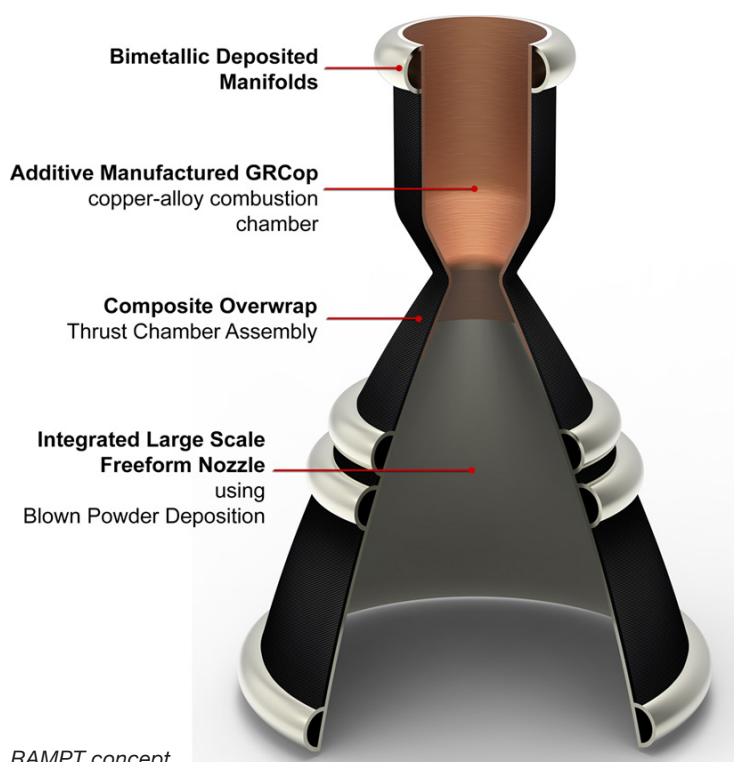
### Propulsion Technology (RAMPT)

NASA's strategic plan calls for the development of enabling technologies, improved production methods, and advanced design and analysis tools related to the agency's objectives to expand human presence in the solar system. NASA seeks to advance exploration, science, innovation, benefits to humanity, and international collaboration, as well as facilitate and utilize U.S. commercial capabilities to deliver cargo and crew to space.

The Rapid Analysis and Manufacturing Propulsion Technology (RAMPT) project will mature novel design and manufacturing technologies to increase scale, significantly reduce cost, and improve performance for regeneratively cooled thrust-chamber assemblies, specifically the combustion chamber and nozzle for government and industry programs. This addresses the longest lead, highest cost, and heaviest component in the engine system. RAMPT will partner with industry through a public-private partnership to design and manufacture component parts into a single thrust chamber assembly, characterize these specialty manufacturing processes, disseminate material/process design data, and complete hot-fire testing to demonstrate a multi-metallic additive-based composite overwrap thrust chamber assembly.

#### Technical Approach

NASA has been evaluating the feasibility of several techniques for fabrication of propulsion components and working to advance these technologies for current and future flight applications. Several advanced manufacturing techniques have evolved and are being considered, such as additive manufacturing and composite manufacturing together with new metallic-alloys, multi-metallic, and composite-based materials. The goal of these manufacturing technologies is to reduce overall mission and support costs, associated schedules, and improve performance.



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## RAMPT Key Technologies

**Freeform blown powder nozzle:** The first key technology being matured under RAMPT is the freeform blown powder deposition additive manufacturing of the large scale regen-cooled nozzle structure. The goal of this process development is to advance the blown powder deposition for large-scale thin-walled structures to net shape or near-net shape to significantly reduce the time required for nozzle fabrication.

**Composite overwrap structural jacket:** The second key technology being developed under RAMPT is the composite overwrap of the thrust chamber assembly. This includes the GRCop-84/42 copper-alloy based material of the combustion chamber and the superalloy freeform nozzle. This technology offers the potential to substantially decrease weight up to 70 percent over metallic jacket structural supports.

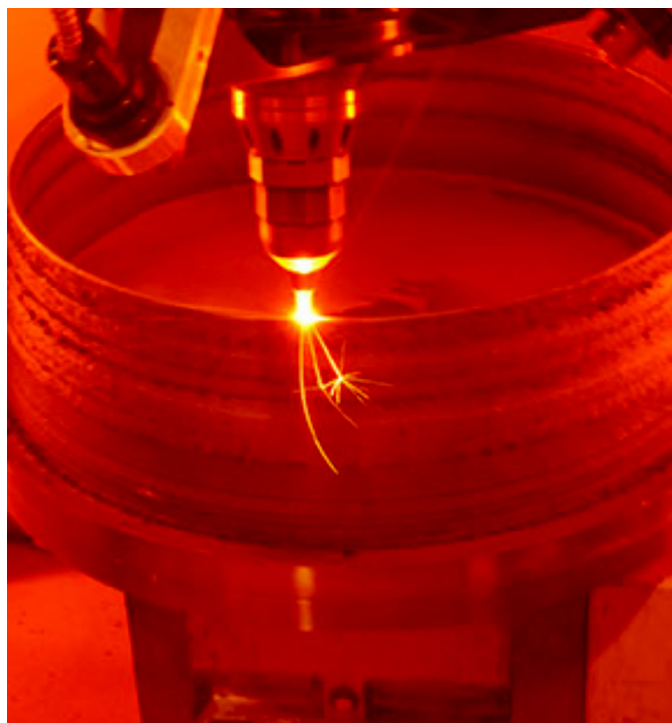
**Bimetallic radial deposition for manifolds:** The third key technology area is the development of the bimetallic deposition for manifold land and/or integrated manifold to the GRCop-84/42 combustion chamber.

**Modeling and analysis tools for additive and regen design:** The fourth key technology area is the development of congruent design and analysis tools that help optimize the overall design and fabrication process. This includes tools for process modeling and design tools that integrate various codes and analysis subroutines to allow for optimization of complex regen-cooled combustion devices components.

### NASA Roles

NASA will be responsible for integration of components and specialty manufacturing processes across the entire project to optimize the overall thrust chamber assembly. Specialty manufacturing industry partners will be a key part of the development, which allows long-term industry and government access to these technologies to be used for fabrication of components in various programs including commercial space.

NASA's Marshall Space Flight Center in Huntsville, Ala., provides project management. Marshall is responsible for



*Freeform additive deposition nozzle jacket.*

overall technical and engineering design and analysis of hardware, procurement of and integration of hardware, requirements, and hot-fire testing of hardware.

NASA's Glenn Research Center in Cleveland, Ohio, will provide materials characterization and bimetallic weld process development for the RAMPT element.

NASA's Langley Research Center in Hampton, Va., and Ames Research Center in Silicon Valley, Calif., are responsible for developing process modeling for specialty manufacturing processes, tool development and validation with Langley focusing on materials modeling and Ames focusing on process modeling.

The Game Changing Development (GCD) program is part of NASA's Space Technology Mission Directorate. The GCD program aims to advance exploratory concepts and deliver technology solutions that enable new capabilities or radically alter current approaches.

For more information about GCD, please visit <http://gameon.nasa.gov/>

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**Marshall Space Flight Center**  
Huntsville, AL 35812

[www.nasa.gov](http://www.nasa.gov)

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